Past and future flooding in Bangladesh

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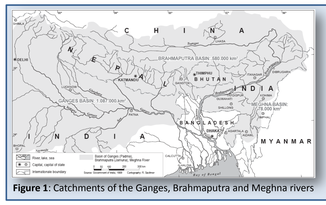


Figure 1: Catchments of the Ganges, Brahmaputra and Meghna rivers

Currently, an average of about 20 % of the land surface in Bangladesh is flooded each year, affecting one of the most densely populated regions in the world.

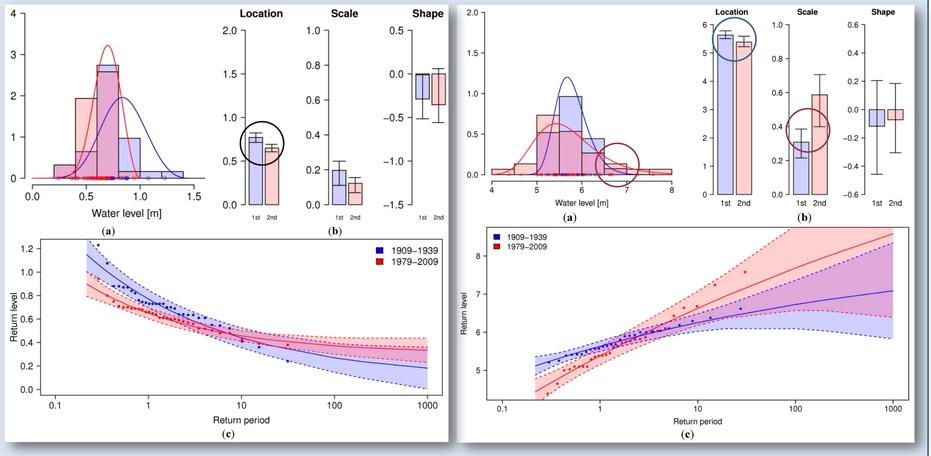
We aim

- to understand past and future flooding in the Ganges-Brahmaputra-Meghna (GBM) basin, and
- to assess how climate change compares to the impact of man-made structures such as Farakka barrage, built across the Ganges on the border between India and Bangladesh and operating since 1975.

Understanding past trends in extreme water levels

Data: daily water levels (Station Dhaka, SW42) for 1909-2009
Method: extreme value theory, block maxima approach

Figures 2 and 3: (**a**) shows the GEV distributions fitted to annual minimum (left) and maximum (right) water levels for 1909–1939 (blue) and 1979–2009 (red); estimated parameters location μ, scale σ and shape ξ are plotted in (**b**). Error bars depict 95% confidence intervals obtained from non-parametric bootstrapping (R = 500). Return level plots with 95% confidence intervals are shown in (**c**).



⇨ The magnitude and duration (not shown, see [1]) of average flood events decreased, ○ the frequency of extreme flood events has increased. ○ A significant decrease in the annual minimum water level is detected between the time periods 1909–1939 and 1979–2009. ○

Understanding what the future might bring

Data: average daily precipitation in GBM catchment (*Fig 1*) for 1978 - 2010
Model output: four historical and six future 1° CCSM4 ensemble members for Representative Concentration Pathways RCP2.6 and 8.5 (1850 - 2100)

Method: Proxy discharge constructed from observed average daily upper-catchment precipitation by varying a moving average and lagging the observed precipitation to observed discharge.
Assuming this relationship remains the same in the future, the optimal settings were used to calculate the proxy discharge from both present and future model output.

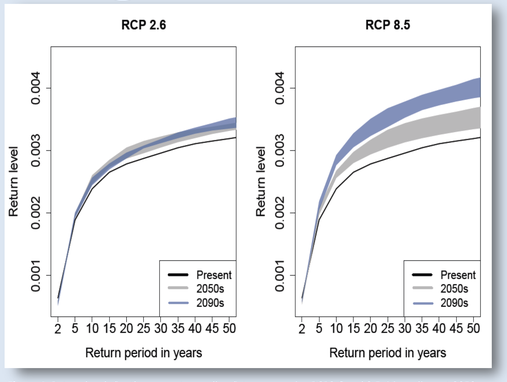


Figure 4: Return levels for the present as well as future scenarios RCP2.6 and 8.5 (time slices at 2050 and 2090). Units on the y axis relate to the proxy discharge.

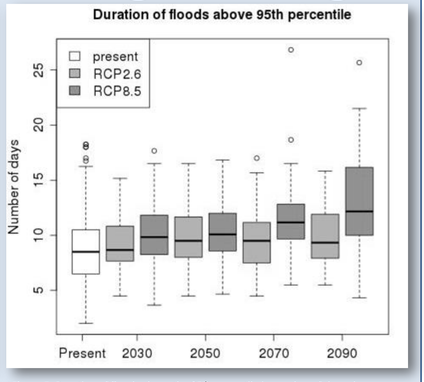


Figure 5: Duration of floods above the 95th percentile in number of days above danger level.

⇨ When comparing return levels for both the present and future, it can be seen that **return levels increase** (*Fig 4*) . This effect is more pronounced in model simulations using RCP8.5, where what is e.g. a 15 year flood in present-day climate has a return period of ~11 (8) years by 2050 (2090).
A **significant increase in flood duration** is detected during the 21st century, but only for RCP8.5 (*Fig 5*) .

Understanding the impact

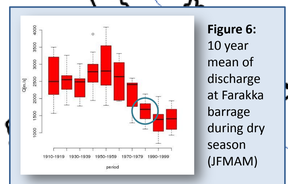


Figure 6: 10 year mean of discharge at Farakka barrage during dry season (JFMAM)

⇨ Farakka barrage has substantial impact on dry season flow since it began operations in April 1975, ○ mostly due to water sharing issues with India.

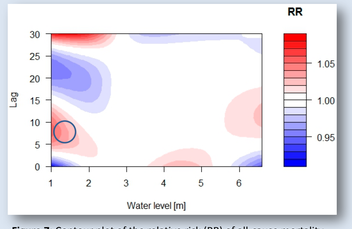


Figure 7: Contour plot of the relative risk (RR) of all-cause mortality along water level and lags, with reference to the median water level using a distributed lag non-linear model. See [1] for details.

⇨ As water levels decrease, risk of dying increases. ○ This affects one of the fastest growing populations world-wide, in particular slum dwellers [2].

Farakka
Dhaka
sea-level rise

⇨ Regional slr expected to be as high as 1 m until 2100. Relative slr is further exacerbated due to e.g. subsidence and less siltation due to man-made structures further upstream. Resulting effects such as salinification and inundation are expected to cause up to 15 Mio coastal refugees by 2050.

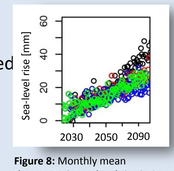


Figure 8: Monthly mean thermosteric sea-level rise in Bay of Bengal from CCSM4 for RCP2.6 (blue), RCP4.5 (green), RCP6 (red) and RCP8.5 (black) for 2020 – 2100.

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80 km
40 mi

What do we conclude?

- Our analyses shows varying behavior in past extreme water levels and duration, with both flood frequency and flood duration increasing in the future, in particular for RCP8.5 (*Fig 2,3,4,5*).
- Decreasing minimum water levels could be due to Farakka barrage, and are of particular concern due to an increasing risk in mortality associated with low water levels (*Fig 2, 6, 7*).
- In addition to sea-level rise (*Fig 8*), man-made structures and accompanying political concerns over water-sharing are likely to be of great importance when addressing the implications of future changes in extreme water levels in Bangladesh.

Acknowledgement: This work was partly carried out within the framework of the priority program 1233 „Megacities Megachallenge“, for which funding was provided by the German Research Foundation DFG.
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[2] Aßheuer, T.; Thiele-Eich, I.; Braun, B. (2013): Coping with the impacts of severe flood events in Dhaka's slums—The role of social capital. *Erdkunde,* 67, 21–35.
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